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SURVEY MONITORING OF ENVIRONMENTAL FACTORS FROM BEDDED SWINE SYSTEMS

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ABSTRACT

Six deep bedded swine finishing production sites were surveyed for hydrogen sulfide, ammonia and odor concentrations. Each site was observed four different times with readings 6 times over a 36 hour period. Hydrogen sulfide, ammonia and odor were measured at the building edge and downwind 30 m (100 ft). Hydrogen sulfide and ammonia were measured 150 m (500 ft) downwind also. The site averages for hydrogen sulfide were found to range from 25 to 228 ppb at the building edge, 4 to 17 ppb 30 m (100 ft) downwind and 4 to 8 ppb 150 m (500 ft) downwind. Ammonia site averages were found to range from 2 to 11 ppm at the building edge, undetectable to 3 ppm downwind 30 m (100 ft) and undetectable at 150 m (500 ft). Odor threshold site averages ranged from 130 to 630 at the building and 80 to 500 at a point 30 m (100 ft) from the building. Single point hydrogen sulfide monitors were used 30 m (100 ft) from the building at the four compass points. The downwind monitor yielded weighted averages ranging from 0.8 to 8.1 ppb for the six sites. Analyzing this data by separating it by atmospheric stability classes did not appear to indicate a trend.

KEYWORDS. Swine Housing, Air Quality, Emission Concentration, Deep Bedded Packs

INTRODUCTION

Deep bedded hoop structures (Figure 1) can be an attractive alternative for some farms raising livestock. As compared to more traditional facilities, they have a lower purchase price, they are more flexible for alternative uses, and they provide an alternative management system that may be attractive to some producers (Brumm et al., 1997, 1999, Honeyman et al., 1999). It is generally believed that deep-bedded hoop structures used for raising swine produce fewer air quality problems than comparable liquid-manure swine production facilities. However, this assumption has not been proven thus far. Limited air quality monitoring has been done on hoop structures. Types of bedding material, frequency of adding bedding, and amount of bedding and environmental conditions may greatly affect the air quality generated from hoop buildings. A survey of several buildings will help determine the variability of air quality from different producers' facilities.

Figure 1 A typical deep-bedded hoop structure used for swine.

OBJECTIVES

The objectives for this study include the following:

- Select six different deep-bedded swine finishing production sites which are unencumbered by other swine production units, manure piles and objects which would change the air flow around the site.

- Ask the selected producers to keep a production diary that includes swine placement and removal from the unit, the bedding type and amount added and any other pertinent management decisions.
- On a monthly basis, measure the ammonia concentration, hydrogen sulfide concentration and odor threshold detection level at the building, 100-feet and 500-feet down wind from the production system.
- Tabulate the hydrogen sulfide concentration for different atmospheric stability classes.

PROCEDURES

Six sites were found that used hoop structures with deep bedding for finishing swine. Sites were selected that had few additional odor sources that would contribute to the overall air quality impact of the site. Every attempt was made to find sites that had few wind breaks or other structures that would influence the direction of the wind on the farm. Table 1 shows the descriptions of each site.

Table 1. Descriptions of the six survey sites.

Site	No. of Hoops	Size of Hoops	Total Capacity
Illinois (IL)	8	9.1 m by 21.9 m	1440 head
Iowa – Northern (NIA)	12	9.1 m by 25.6 m	2520 head
Iowa – Southern (SIA)	2	15.2 m by 30.5 m	833 head
Minnesota #1 (MN1)	4	9.1 m by 18.3 m	600 head
Minnesota #2 (MN2)	6	9.1 m by 21.9 m	1080 head
Nebraska (NE)	6	12.2 m by 27.4 m	1650 head

Each site visit was done over a two-day period. Most were done monthly but a few were conducted on a slightly different schedule. A total of four sets of samples from each unit were performed.

The two-day testing protocol was as follows:

- Hydrogen sulfide and ammonia were measured at 12 noon, 3 p.m., 6 p.m., at dusk (on the first day), 6 a.m., 9 a.m., and 12 noon (on the second day). The samples were taken from two buildings, 30 m (100-ft) and 150 m (500-ft) from the buildings (at 9 m (30-ft) intervals across the plume for both distances. The hydrogen sulfide was measured using a Jerome meter. The ammonia was measured using a digital ammonia meter.
- Odor samples were collected from the building edge and 30 m (100-ft) downwind from the plume and were taken in duplicates at 6 a.m., 9 a.m., and noon on the second day for subsequent analysis with the olfactometer. The samples were taken in duplicates at each of the three time periods and in the plume downwind at only one location.
- Notes were taken on the size of the pigs, condition of the bedding and any activity that was occurring during sampling.

Each site was evaluated using site visits and also using single point monitors. Each site was visited four times, approximately 36 hours per visit. Ammonia was measured using a Draeger PAC III Ammonia Sensor (Reference to a specific company is not meant as an endorsement by Iowa State University or the authors, but is used as an illustration and for accuracy of the description of the research.)with an accuracy of $\pm$ 1 ppm. Hydrogen sulfide was measured using a Jerome Hydrogen Sulfide Analyzer Model 631-X with accuracy of $\pm$ 3 ppb. The odor samples were collected in tedlar bags at building edge and at 100 feet downwind and were evaluated in the ISU Olfactometry Laboratory within 48 hours of collection. A total of twelve 10 liter-odor samples were collected during each visit. A Campbell Scientific Instruments weather station was used to collect temperature, humidity, solar intensity, wind speed and wind direction.

Hydrogen sulfide was recorded continuously using Single Point Monitors (SPM) located 30 to 60 m (100 - 200 ft) from the units. These were located north, south, east and west from the units except when it was not practical due to crops or other site restrictions. Single Point Monitors (SPM) with accuracy of ± 20 percent was used for continuous monitoring of hydrogen sulfide.

RESULTS AND DISCUSSION

Data analysis was performed in several different ways. The readings from the site visits were tabulated and averaged. The SPM data was averaged for the site by all conditions and then were also tabulated according to the stability characteristics of the environment at any particular time. These will be discussed further in the following sections.

Site-visit Data

Four of the sites were monitored during the late summer and early fall of 2001 and then again during the late spring, early summer of 2002. Monitoring continued until near the first frost and resumed in the spring. The IL and MN-2 sites were not located until spring of 2002. The IL site had a wooded area on the north and east of the site which may have influenced the readings. The producers involved in the study did not keep detailed diaries of activities. Notes were made of the size, bedding condition and activities during site visits.

Figure 2 shows the averages of the hydrogen sulfide and ammonia readings taken at the building edge during site visits. It appears that the same trend exists for ammonia and hydrogen sulfide in that they are lowest for the Minnesota sites and highest for the Illinois site. One might conclude that this corresponds to facility capacity, however, the Northern Iowa and Nebraska sites were the largest. Since this was a survey project and each site was only visited four times, there were differences in the average weight of pigs on each site at the time of the observations. Pig weight was estimated during survey visits. Pig average weights for the survey trips were as follows: IL: 86 kg (190 lbs); NIA: 82 kg (180 lbs); SIA: 73 kg (160 lbs); NE: 64 kg (140 lbs); MN1: 64 kg (140 lbs); MN2: 48 kg (106 lbs). It is interesting to note that the trend that appears in Figure 2 for gases at the building edge nearly follows the trend in average pig size at the sites. Larger pig sizes correspond with deeper bedded manure packs and greater potential for emissions from manure decomposition. Bedding condition may also be a contributing factor, affecting the rate of decomposition and extent of anaerobic activity.

Figures 3 and 4 show the ammonia and hydrogen sulfide readings at 30 m (100 ft) and 150 m (500 feet) downwind. It is interesting to note that the Southern Iowa site (SIA), while having a relatively low hydrogen sulfide reading at the building edge, had the highest hydrogen sulfide reading at 30 m (100 ft) and 150 m (500 ft). The other sites all tend to follow the same trend they exhibited in Figure 2. Another interesting point is that the average hydrogen sulfide reading at the MN-1 site was actually higher at 150 m (500 ft) than it was at 30 m (150 ft). This does not make intuitive sense but is possible with this limited data set. Since only four visits were conducted, weather conditions may have influenced the plume coming from the building, and influenced the averages. Manure stockpiles may have also contributed.

Figure 5 shows the average olfactometry results from the six sites. The detection threshold is interpreted as parts of fresh air required to dilute one part of the sample to a level where half of the human panelists can detect odors. Therefore, a high threshold would be a very odorous sample. Figure 5 illustrates the point that ammonia or hydrogen sulfide concentrations do not necessarily predict odor concentration. The odor threshold for MN-1 is the highest of the six sites, yet for gas concentrations, it was low. This could be for a number of reasons. One factor could be that this site used paper for bedding.

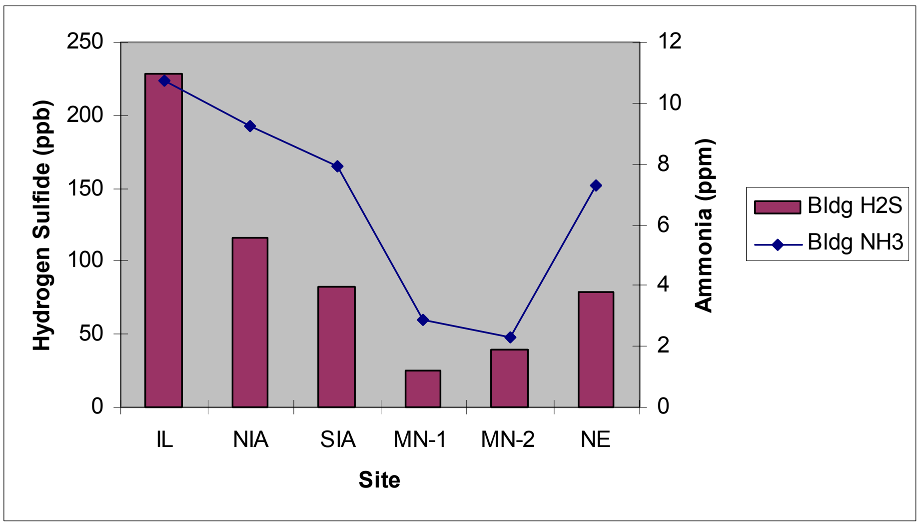

Figure 2 Survey averages for hydrogen sulfide (ppb), measured with a Jerome meter, and ammonia (ppm), measured with a Draeger PAC III, at the building edge .

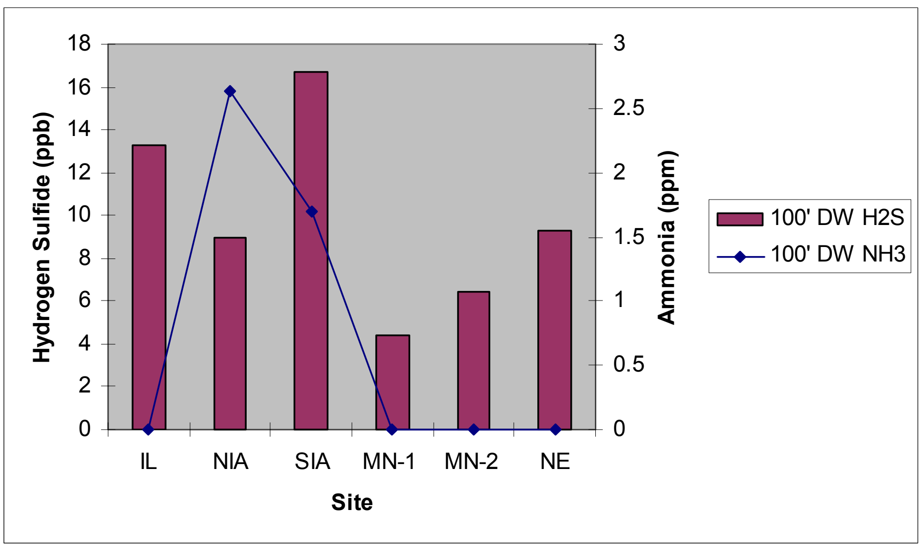

Figure 3 Survey averages of hydrogen sulfide, measured with a Jerome meter, and ammonia, measured with a Draeger PAC III, 30 m (100 ft) downwind.

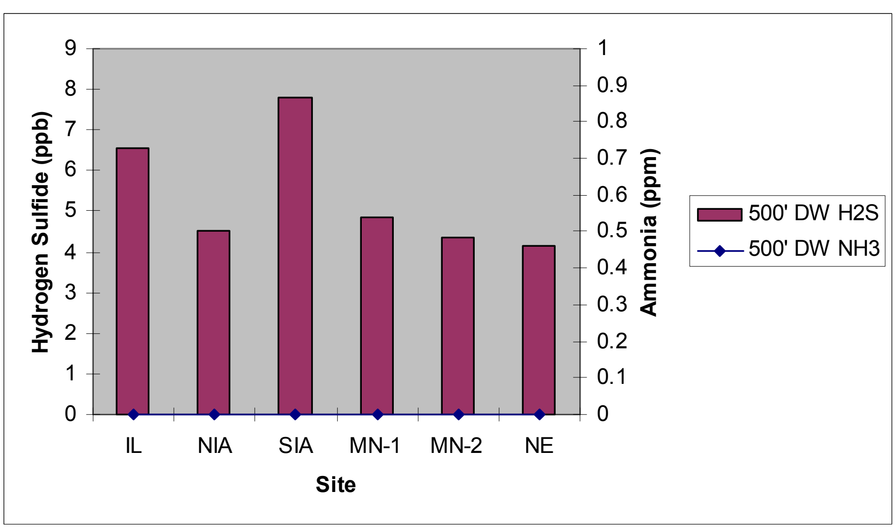

Figure 4 Survey averages of hydrogen sulfide and ammonia using handheld collection devices at 150 m (500 ft) downwind.

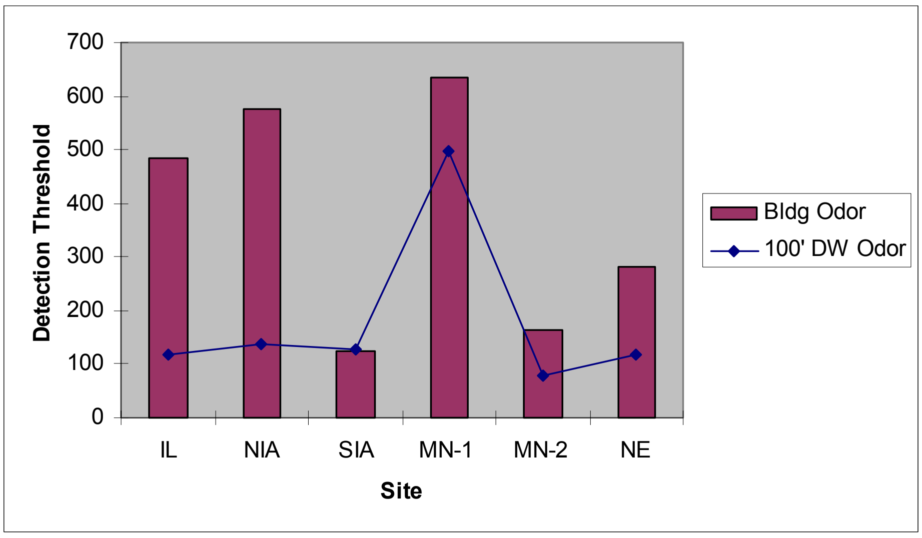

Figure 5 Olfactometry results of the survey visits.

SPM Data – Weighted Averages

The single point monitor (SPM) data was analyzed by first determining which monitor was downwind from the site at any given time. This was done by calculating which wind directions would place the SPM in the air plume emanating from one of the buildings. Data was collected continuously and recorded every 15 minutes. Weighted averages, maximums and minimums were tabulated for each site.

Table 2 contains the summary of the information gathered from the single point monitors for hydrogen sulfide. The Illinois site had the highest readings by more than a factor of 3 when compared to the next highest average. This may be due to the wooded area directly to the north of the site, which could create an undisturbed pocket of air where concentrations could be elevated. All of the averages were lower than the survey averages, but the SPM data included many time periods in which the reading was zero. This would lower the time weighted average. The SPMs are accurate to 20 percent of the reading and questions have been raised about the accuracy at very low levels. More important than average is the maximum hydrogen sulfide readings. If regulations require that hydrogen sulfide not exceed some given amount, then this data could be helpful in deciding where a deep bedded facility could be located. The maximum measured hydrogen sulfide concentration was 90 ppb for several sites however; 90 ppb was the maximum concentration the SPM was capable of for this range. This indicates that the maximum was likely greater than 90 ppb.

SPM Data – Stability Class Averages

Pasquill stability classes define the atmospheric stability. The stability class was evaluated for each data point by using the weather station data for solar intensity and wind speed. Table 3 gives the definitions of each stability class (Beychok, 1994). Table 4 tabulates the hydrogen sulfide reading for each location by season and by stability class. One would expect that as you move from the very unstable class (A) to the stable class (F), a trend of increasing hydrogen sulfide would be seen at the SPM. However, the simple averages do not appear to indicate this. Further analysis is needed to examine the statistical differences. The precision of the SPM may make this difference undectable.

Table 2. Hydrogen sulfide readings (ppb) from the single point monitors located 30 m (100 feet) from the hoop structures. (Reference to a specific company is not meant as an endorsement by Iowa State University or the authors, but is used as an illustration and for accuracy of the description of the research.).

	Wt. Avg.	Maximum	Minimum	Number of Samples
IL	8.1	90	0	3896
NIA - Fall	2.1	19	0	1301
NIA - Spring	2.6	50	0	5110

SIA – Fall	1.4	48	0	1366
SIA - Spring	1.2	90	0	4429
MN 1 – Fall	1.8	90	0.9	2656
MN 1 – Spring	0.8	6	0	1149
MN 2	0.7	22	0	7941
NE – Fall	1.2	22	0	665
NE – Spring	1.9	35	0	299

Table 3. Atmospheric Stability Classes (Stability classes: A – very unstable; B – unstable; C – slightly unstable; D – Neutral; E – slightly stable; F – stable)(adapted from Beychok, 1994).

	Day Time Solar			
Wind Speed (m/s)	Strong > 598 W/m^2	Medium 301 – 598 W/m^2	Slight < 301 W/m^2	Night
< 2	A	AB	B	--
2 – 3	AB	B	C	EF
3 – 5	B	BC	C	DE
5 – 6	C	CD	D	D
> 6	C	D	D	D

Table 4. Average hydrogen sulfide readings (ppb) from the single point monitors, grouped by atmospheric stability class.

	IL	NIA		SIA		MN-1		MN-2	NE		Simple
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Spring	Fall	Spring	Avg.
A	5.8	3.9	3.9	---	3.0	3.7	1.0	1.3	2.8	1.3	3.0
AB	6.3	3.9	3.9	2.9	2.2	3.2	0.6	1.2	2.0	1.6	2.8
B	8.0	2.7	3.3	5.2	1.6	2.4	0.5	0.8	1.1	2.4	2.8
BC	12.6	4.0	3.4	1.6	1.7	1.8	0.0	0.8	1.3	3.3	3.1
C	12.6	2.4	2.6	2.7	1.8	1.4	1.0	0.6	1.5	4.0	3.1
CD	13.9	--	2.6	1.3	0.6	1.6	0.5	0.7	1.0	2.5	2.7
D	14.0	1.8	1.3	0.2	0.7	1.0	1.1	0.4	1.0	2.6	2.4
DE	7.7	1.3	1.4	0.3	0.5	1.0	0.3	0.6	1.0	0.5	1.5
EF	8.7	1.3	2.3	0.4	0.6	0.0	0.2	0.5	1.0	0.4	1.5
Sim. Avg.	10.0	2.7	2.7	1.8	1.4	1.8	0.6	0.8	1.4	2.1	2.5

CONCLUSION

Six deep bedded swine production sites were surveyed for hydrogen sulfide, ammonia and odor concentrations. Each site was observed four different times with readings 6 times over a 36 hour period. Hydrogen sulfide, ammonia and odor were measured at the building edge and downwind 30 m (100 ft). Hydrogen sulfide and ammonia were measured 150 m (500 ft) downwind also. The site averages for hydrogen sulfide were found to range from 25 to 228 ppb at the building edge, 4 to 17 ppb 30 m (100 ft) downwind and 4 to 8 ppb 150 m (500 ft) downwind. Ammonia site averages were found to range from 2 to 11 ppm at the building edge, undetectable to 3 ppm downwind 30 m (100 ft) and undetectable at 150 m (500 ft). Odor threshold site averages ranged from 130 to 630 at the building and 80 to 500 at a point 30 m (100 ft) from the building. Single point hydrogen sulfide monitors were used 30 m (100 ft) from the building at the four compass points. The downwind monitor yielded weighted averages ranging from 0.8 to 8.1 ppb for the six sites. Analyzing this data by separating it by atmospheric stability classes did not appear to indicate a trend.

Acknowledgements

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